## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to a DC-DC converter and the power supply circuit which has a masterslave type DC-DC converter especially.
[0002]
[Description of the Prior Art]In the electromobile or the hybrid car, at the time of a slowdown, the regenerative power from a motor alternator is transformed with a DC-DC converter, and it is storing in the battery. As art about this kind of DC-DC converter, there are some which were indicated by JP,2000-253503,A, for example.
[0003]
[Problem(s) to be Solved by the Invention]Generally, as for a DC-DC converter, conversion efficiency changes according to input power. In particular, in the case of the bidirectional DC-DC converter of 1 circuit ****** method, the grade of the change is large in a main circuit. The adverse factor of conversion efficiency has the switching loss of a primary side, and the loss by the forward voltage drop of a downstream rectifier diode. Although a DC-DC converter is generally designed become maximum efficiency [ near the rated output ], by the increase in an input current, or the increase in input voltage, a primary side loses, that is, switching loss increases, and conversion efficiency is worsened. On the other hand, instead of switching loss decreasing at the time of low input power, a downstream loss becomes dominant and conversion efficiency is worsened.
[0004]Since the regenerative power by the motor alternator in an electromobile or a hybrid car changes with the operational status of vehicles a lot, the electric power inputted into a DC-DC converter also changes a lot. Therefore, it was difficult to always operate a DC-DC converter with the best conversion efficiency.
[0005]

[Means for Solving the Problem]This invention is characterized by a power supply circuit comprising the following, in order to solve such a technical problem.
It is made and is 1 or two or more master DC-DC converters.
A masterslave type DC-DC converter which has 1 which operates so that output current and output voltage may be in agreement with a master DC-DC converter, or two or more slave DC-DC converters.
A control means which chooses a master DC-DC converter and a slave DC-DC converter which make either input power of a masterslave type DC-DC converter, or output power reference electric power, and operate it according to said reference electric power.

[0006]According to this power supply circuit, only a master DC-DC converter and a slave DC-DC converter selected according to input power or output power of a masterslave type DC-DC converter operate. Maximum efficiency output power as a masterslave type DC-DC converter, Since it becomes the sum of each maximum efficiency output power of a selected master DC-DC converter and a slave DC-DC converter, according to a selected result, maximum efficiency output power of a masterslave type DC-DC converter changes.
[0007]A control means, So that the sum of each maximum efficiency output power of a master DC-DC converter and a slave DC-DC converter may serve as output power of a masterslave type DC-DC converter, or a value near it. It is desirable to choose a master DC-DC converter and a slave DC-DC converter.
[0008]By choosing a master DC-DC converter and a slave DC-DC converter in this way, a masterslave type DC-DC converter can be operated at maximum efficiency or efficiency near it.
[0009]As for a control means, it is desirable that it is what adjusts output voltage so that conversion efficiency of a masterslave type DC-DC converter may approach maximum efficiency.
[0010]By suitable selection of a master DC-DC converter and a slave DC-DC converter, after bringing about conversion efficiency of a masterslave type DC-DC converter close to maximum efficiency, conversion efficiency can be further brought close to maximum efficiency by adjusting output power.
[0011]It is desirable to connect a motor alternator for vehicles to one input/output terminal of a masterslave type DC-DC converter via an inverter, and to connect a charge-and-discharge means for vehicles to an input/output terminal of another side.
[0012]Although regenerative power of a motor alternator for vehicles changes a lot according to a slowdown situation of vehicles, since it is adjusted so that conversion efficiency of a masterslave type DC-DC converter may approach maximum efficiency according to a value of regenerative power, it can charge a charge-and-discharge means for vehicles efficiently.

[0013]
[Embodiment of the Invention]Drawing 1 is a block diagram showing the power supply circuit which is one embodiment of this invention. In [ this power supply circuit is constituted by masterslave type DC-DC converter 3, the controller 4, and the current/voltage sensors 5 and 6, and ] a hybrid car or an electromobile, It is provided with the inverter 2 between the motor alternator 1 for a vehicles drive, and the battery 7 which is charge-and-discharge means.
[0014]The motor alternator 1 operates as the source of power of vehicle running, i.e., an electric motor, and operates as a dynamo at the time of vehicle deceleration, and outputs regenerative power.
[0015]When the inverter 2 drives the motor alternator 1, it changes into three phase alternating current electric power the direct current power of the battery 7 by which pressure up was carried out with masterslave type DC-DC converter 3. When operating the motor alternator 1 as a dynamo (i.e., when carrying out regenerative operation of the inverter 2), it changes into direct current power the regenerative power of the exchange generated with the motor alternator 1.
[0016]Masterslave type DC-DC converter 3 is provided with the following.
Master DC-DC converter 31 which is a bidirectional DC-DC converter and performs bidirectional operation.
Slave DC-DC converters 32 and 33 which similarly perform bidirectional operation.
Master DC-DC converter 31 and slave DC-DC converters 32 and 33 will be named generically, and it will be called an element converter here.
[0017]By the controller 4, target voltage is given and master DC-DC converter 31 receives constant voltage control. Target current is given so that it may become the same output current in the same output voltage as master DC-DC converter 31 by the controller 4, and slave DC-DC converters 32 and 33 receive constant current control.
[0018]Master DC-DC converter 31 and slave DC-DC converters 32 and 33 all have the same conversion efficiency characteristic, and the conversion efficiency eta changes according to output power.
[0019]Drawing 2 shows the conversion efficiency characteristic of master DC-DC converter 31 and slave DC-DC converters 32 and 33, and output power is taken along a horizontal axis and it has taken conversion efficiency along the vertical axis. As shown in this figure, the conversion efficiency eta shows the characteristic of Yamagata, and when output power is Petamax, it serves as maximum efficiency etamax. Here, Petamax is called maximum efficiency output power.
[0020]The controller 4 controls master DC-DC converter 31 and slave DC-DC converters 32 and 33 based on the required power voltage from the inverter 2, the input-and-output current and voltage information from current / voltage sensors 5 and 6, the battery voltage information

from the voltage sensor 6, etc.
[0021]Drawing 3 is a flow chart which shows the control procedure of the controller 4 at the time of power regeneration operation. At the time of power regeneration, the pressure of the electric power from the inverter 2 is lowered, and it supplies it to the battery 7.
[0022]In Step S1, the element converters 31-33 are started and, subsequently to this time, the current information and voltage information which were detected by current / voltage sensor 6 are incorporated at Step S2. The product of the current value and pressure value at this time serves as the output power Pout.
[0023]Next, in Step S3, calculation of the number N of the element converter which should be driven is performed based on a following formula (1).
[0024]
N= (Pout/Petamax) +1 -- (1)
Since it can guess that the output power Pout acquired at Step S2 is what was obtained out of conversion efficiency on the conditions which are not good, compared with the output power obtained in a situation with good conversion efficiency, it has a small value. Therefore, the quotient which obtained the output power Pout acquired at Step S2 by breaking it by the maximum efficiency output power Petamax of an element converter serves as a value smaller than the quotient which obtained output power when it assumed that maximum efficiency operation was able to be carried out by breaking it by Petamax. Then, the numerical value which added 1 to the quotient is made into the number of a drive required to operate with maximum efficiency.
[0025]It is judged whether next the number N which he followed to step S4 and was computed is larger than the maximum of N. Since the maximum of N is "3" in this embodiment, it is judged whether the value of N computed at Step S3 is larger than three. When large, after progressing to Step S5 and transposing the value of N to the maximum of N, i.e., 3, it shifts to Step S6. On the other hand, the value of N is smaller than three, or when equal to 3, Step S5 is skipped and it shifts to Step S6.
[0026]In [ in Step S6, acquire battery voltage VB detected by the voltage sensor 8, and ] Step S7, The target voltage to master DC-DC converter 31 is set as VB, and is directed so that the output voltage Vo of masterslave type DC-DC converter 3 may become the same as battery voltage VB.
[0027]Next, it progresses to Step S8 and only the number settled at Step S3 - Step S5 drives an element converter. At this time, master DC-DC converter 31 is made to certainly drive, and performs adjustment of the number with slave DC-DC converters 32 and 33. For example, if it is N= 1, will drive only master DC-DC converter 31, and if it is N= 2, Master DC-DC converter 31 and slave DC-DC converter 32 are driven, and if it is N= 3, master DC-DC converter 31 and slave DC-DC converters 32 and 33 will be driven. At this time, since the output voltage and

battery voltage of masterslave type DC-DC converter 3 are the same value, charging current does not flow.

[0028]Next, it shifts to step S9 and it is judged whether the output voltage Vo is smaller than the maximum-permissible charge voltages Vomax of the battery 7. At present, since the output voltage Vo is set as the same value as battery voltage VB in Step S6, the output voltage Vo is allowable-voltage within the limits, and judgment is affirmed and shifts to Step S10.

[0029]Only the value dVo set up beforehand makes the output voltage Vo increase in Step S10. That is, only dVo makes the target output voltage of master DC-DC converter 31 increase, and, thereby, the output voltage Vo increases. By this, in order that the output voltage Vo may exceed battery voltage VB, it flows out, the charging current Io, i.e., the output current, to the battery 7.

[0030]In Step S11, it is judged whether charging current (output current Io) is smaller than the maximum-permissible charging current Iomax of the battery 7. Here, if affirmed, it will be regarded as under normal operation, will shift to Step S12, and the conversion efficiency eta as masterslave type DC-DC converter 3 will be computed based on a following formula (2).

[0031]

Eta=Pout/Pin -- (2)

It is the input power obtained based on the current value and pressure value from which Pout is the output power obtained based on the current value and pressure value which were detected by current / voltage sensor 6, and Pin was detected by current / voltage sensor 5 here.

[0032]And it progresses to Step S13 and it is judged whether the conversion efficiency eta acquired at Step S12 is maximum efficiency etamax. Maximum efficiency etamax as masterslave type DC-DC converter 3 is equal to maximum efficiency etamax of each element converter.

[0033]When the conversion efficiency eta is not maximum efficiency etamax, in the case of a value smaller than maximum efficiency etamax, the conversion efficiency eta returns at step S9, and step S9 to the step S13 is repeated until the conversion efficiency eta is mostly in agreement with maximum efficiency etamax.

[0034]When the output voltage Vo becomes more than the maximum-permissible charge voltages Vomax of the battery 7, or also when the charging current Io becomes beyond the maximum-permissible charging current Iomax of the battery 7, step S9 - the voltage adjustment by Step S13 are terminated.

[0035]By according to this embodiment, computing the number N of a parallel run with the most sufficient conversion efficiency according to regenerative power, and adjusting output voltage further in the range which does not exceed the maximum-permissible charge voltages and maximum-permissible charging current of the battery 7, Masterslave type DC-DC

converter 3 can be operated at maximum efficiency or the efficiency near it, and regenerative power can be efficiently stored in the battery 7.
[0036]Drawing 4 is the graph which coincided maximum efficiency output power and compared the conversion efficiency characteristic of the masterslave type DC-DC converter in the power supply circuit of this embodiment with the conversion efficiency characteristic of one set of a mass DC-DC converter, and output power is taken along a horizontal axis and it has taken conversion efficiency along the vertical axis. The characteristic A is the conversion efficiency characteristic of the masterslave type type DC-DC converter in this embodiment, and the characteristic B is the conversion efficiency characteristic by the DC-DC converter by individual operation. As this graph shows, according to the masterslave type DC-DC converter used for this embodiment, it turns out that the conversion efficiency of an always high level is acquired in wide range output power (load condition).
[0037]Below, the time of electric motor operation is explained.
[0038]Drawing 5 is a flow chart which shows the control procedure of the controller 4 which can be set at the time of electric motor operation. At the time of electric motor operation, pressure up of the voltage of the battery 7 is carried out, and it supplies electric power to the motor alternator 1 via the inverter 2.
[0039]Since it is substantially the same, Step S21 - Step S25 abbreviate detailed explanation to Step S1 of the flow chart at the time of the regenerative operation shown in drawing 3 - Step S5. However, since the flow of current is reverse, the current/voltage sensor used for measurement of the output power Pout in Step S22 differ from regenerative operation. That is, in the time of regenerative operation, since the battery 7 side became an output terminal, the output power Pout was computed based on the detection result of current / voltage sensor 6, but in the time of electric motor operation, since the inverter 2 side becomes an output terminal, the output power Pout is computed based on the detection result of current / voltage sensor 5.
[0040]In Step S26, output voltage is directed to master DC-DC converter 31. Unlike the time of the above-mentioned regenerative operation, at the time of electric motor operation, the pressure value of the same value as the required power voltage from the inverter 2 is set as target output voltage.
[0041]Then, it progresses to Step S27 and only the number settled at Step S23 - Step S25 drives an element converter. At this time, master DC-DC converter 31 is made to certainly drive, and performs adjustment of the number with slave DC-DC converters 32 and 33. Operation in the optimal number is performed about conversion efficiency by this.
[0042]Below, a 2nd embodiment of this invention is described with drawing 6 and drawing 7. Drawing 6 is a circuit diagram showing the composition of a 2nd embodiment, and drawing 7 is a flow chart which shows the operation. In drawing 6, the same numerals are given to the

same element as drawing 1, and the detailed explanation is omitted.
[0043]According to this embodiment, the internal configuration of masterslave type DC-DC converter 20 is different from masterslave type DC-DC converter 3 of a 1st embodiment.
[0044]Although the conversion efficiency characteristic was provided with the three same element converters of each other, masterslave type DC-DC converter 3 of a 1st embodiment, Masterslave type DC-DC converter 20 of this embodiment is provided with six element converters, and is classified into two groups according to the conversion efficiency characteristic. Master DC-DC converters 21 and 23 and slave DC-DC converter 22 have the 1st conversion efficiency characteristic, and make it call these the 1st element converter. On the other hand, slave DC-DC converters 24-26 will have the 2nd conversion efficiency characteristic, and will call these the 2nd element converter.
[0045]Drawing 8 is a graph which shows the 1st and 2nd conversion efficiency characteristics, took output power along the horizontal axis, and has taken conversion efficiency along the vertical axis. As shown in the figure, maximum efficiency output power Petamax2 in the 2nd conversion efficiency characteristic D is smaller than maximum efficiency output power Petamax1 in the 1st conversion efficiency characteristic C.
[0046]Constant voltage control of master DC-DC converters 21 and 23 is carried out by the controller 30. Constant current control of slave DC-DC converter 22 is carried out so that master DC-DC converter 21 and output current may become the same. Constant current control of slave DC-DC converters 24-26 is carried out so that output current may serve as a small value with a predetermined ratio rather than the output current of master DC-DC converter 23.
[0047]Below, control of the controller 30 at the time of the regenerative operation of the motor alternator 1 is explained with the flow chart of drawing 7.
[0048]First, in Step S31, the current information and voltage information which were detected by current / voltage sensor 5 are incorporated, and the input power Pin is acquired from the product of the current value and pressure value.
[0049]Next, in Step S32, calculation of the number N1 of the 1st element converter which should be driven is performed based on a following formula (3).
[0050]
N1= (Pin/Petamax 1) -- (3)
The number N1 obtained by dividing the input power Pin acquired at Step S31 by maximum efficiency output power Petamax1 of the 1st element converter is almost equal to the number of the 1st element converter required to operate masterslave type DC-DC converter 20 with maximum efficiency.
[0051]Next, it is then judged to Step S33 whether the number N1 computed at Step S32 is larger than the maximum of N1. Since the maximum of N1 is "3" in this embodiment, it is

judged whether the value of N1 computed at Step S32 is larger than three. When large, after progressing to Step S34 and transposing the value of N1 to the maximum of N1, i.e., 3, it shifts to Step S35. On the other hand, the value of N1 is smaller than three, or when equal to 3, Step S34 is skipped and it shifts to Step S35.
[0052]In Step S35, calculation of the number N2 of the 2nd element converter which should be driven is performed based on a following formula (4).
[0053]
N2=(Pin-N1xPetamax1)/Petamax2 -- (4)
By lengthening total of the maximum efficiency output power by the selected 1st element converter from the input power Pin, the near electric power which the 2nd element converter should pay can be found. By breaking this by the maximum efficiency output power of the 2nd element converter, the number of the 2nd element converter which can cover the parts for the remaining electric power efficiently can be found.
[0054]Next, in Step S36, it is judged whether the number N2 computed at Step S35 is larger than the maximum of N2. Since the maximum of N2 is "3" in this embodiment, it is judged whether the value of N2 computed at Step S35 is larger than three. When large, after progressing to Step S37 and transposing the value of N2 to the maximum of N2, i.e., 3, it shifts to Step S33. On the other hand, the value of N2 is smaller than three, or when equal to 3, Step S37 is skipped and it shifts to Step S38.
[0055]In [ in Step S38, acquire battery voltage VB detected by the voltage sensor 8, and ] Step S39, The target voltage to master DC-DC converters 21 and 23 is set as VB, and is directed so that the output voltage Vo of masterslave type DC-DC converter 3 may become the same as battery voltage VB.
[0056]Next, it progresses to Step S40 and only the number settled at Step S32 - Step S37 drives an element converter. For example, if it is N1=1 and N2=2, will drive master DC-DC converter 23 and slave DC-DC converters 24 and 25, and if it is N1=2 and N2=0, Master DC-DC converter 21 and slave DC-DC converter 22 are driven, and if it is N1=2 and N2=2, master DC-DC converters 21 and 23 and slave DC-DC converters 24 and 25 will be driven. At this time, since the output voltage and battery voltage of masterslave type DC-DC converter 20 are the same value, charging current does not flow.
[0057]Then, output power is brought close to maximum efficiency by increasing output voltage gradually by Step S41 - Step S45. Since Step S41 - Step S45 are the same as step S9 - Step S13 which were explained in drawing 3, detailed explanation is omitted.
[0058]Thus, also in this embodiment, like a 1st embodiment, the number of the element converter in a masterslave type DC-DC converter is adjusted, and the masterslave type DC-DC converter operates so that conversion efficiency may become the optimal.
[0059]Other embodiments are considered although the two above-mentioned embodiments

used this invention as a power supply circuit of the motor alternator carried in the electromobile or the hybrid car.

[0060]Drawing 9 shows the embodiment at the time of applying this invention to a portable-type emergency electric supply unit (for example, for 100V of commercial power).

[0061]In drawing 9, the same numerals are given to the same element as drawing 1, and the detailed explanation is omitted. According to this embodiment, the pressure of the high tension generated from the fuel cell 50 is lowered to battery voltage with masterslave type DC-DC converter 3, the inverter 51 performs DC-AC conversion, and the alternating current load 52 is supplied. The battery 7 is performing backup in the meantime in order to take [ after the fuel cell 50 starts ] time to result in a steady operation state. Since time is taken for the fuel cell 50 to move from starting to a stationary state in the case of this embodiment, the input power for masterslave type DC-DC converter 3 changes. On the other hand, the controller 4 determines the number of the element converter which should be driven so that conversion efficiency may become the best according to change of input power.

[0062]

[Effect of the Invention]As mentioned above, since the number of a drive of the element converter of the masterslave type DC-DC converter to build in is suitably chosen according to input power or output voltage according to the power supply circuit of this invention, a masterslave type DC-DC converter can be operated with the optimal conversion efficiency.

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[Translation done.]